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Development of an aquaculture system using nanobubble technology for the optimation of dissolved oxygen in culture media for nile tilapia (*Oreochromis niloticus*)

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Abstract. The purpose of this research was to discover the process of enrichment of dissolved oxygen in fish cultivation media using nanobubble technology. This study was conducted with two treatments, namely a cultivation media without fish and a cultivation media containing 8 fish with an average body length of 24.5 cm. The results showed that the concentration of dissolved oxygen increased from 6.5 mg/L to 25 mg/L. The rate of increase in dissolved oxygen concentration for 30 minutes is 0.61 pp/minute. The rate of decrease in dissolved oxygen concentration in treatment 1 is 3.08 ppm/day and in treatment 2 is 0.23 ppm/minute. It was concluded that nanobubble is able to increase dissolved oxygen.

1. Introduction

Fishery cultivation is growing rapidly in Indonesia. Many new kinds of technology have emerged to increase the production of aquaculture. The increase in fishery production is achieved by developing cultivation technology from the traditional into intensive and even into super intensive technology. Super intensive technology is characterized by high stocking density. High level density in intensive cultivation will result in high production. However, intensive cultivation systems have a disadvantage that can harm cultivators, one of them is the increase in ammonia levels that can reduce the concentration of oxygen in the water. Dissolved oxygen is the most important factor for sustaining fish lives because it relates to respiration. Low level dissolved oxygen can degrade the quality of cultivation water, cause growth disturbance and decrease body resistance to infection [1].

A solution to this problem is the utilization of aquaculture technology called the nanobubble system as an activity or effort performed in the cultivation process to increase the productivity of cultivation yields through the changes and modifications of aquaculture systems. Using nanobubble technology, the water quality in the cultivation containers is maintained so that the survival and growth of fish are optimized [2].

Nanobubble is a technology to increase the concentration of dissolved oxygen in cultivation water. Nanobubble can also play a role in the processing of (organic and inorganic) waste in cultivation containers by supplying dissolved oxygen to the water to be used by microbes that decompose organic waste. Nanobubble is a development of microbubble technology. In a study, microbubble technology was applied in the cultivation of *Crassostrea gigas* and pearl shells, *Pinctada martensii* [2].

In general, this study aims to determine the enrichment process of dissolved oxygen in fish cultivation media using nanobubble technology. The existence of nanobubble is expected to enrich the concentration of dissolved oxygen in the water.

2. Methodology

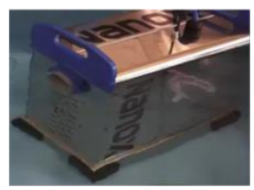
2.1 Time and Location

This research was conducted for 4 weeks from 1 February 2016 to 26 February 2016. The location of this research was at LIPI Innovation Center Laboratory, Jalan Raya Jakarta-Bogor KM 47, Cibinong, Indonesia.

2.2 Tools and Materials

The tools and materials used during this research include a 47x32x27 cm tub, aerator, measuring tape, DO meter, water pump, nanobubble generator, bucket, stationery, camera, eight tilapia with the size of 24.5 cm and fish feed. The figure of the nanobubble generator device is shown by table 1.

Table 1. Major specification of nanobubble generator device.

Name	Specification					Figure
	Mixer	Size (mm)	Weight (kg)	Power (V)	Flow rate (L/h)	
Nanobubble generator device	Acry flat honeycomb equipped	490×560 ×270	40	200	12000	
Nanobubble device (lab scale)	RNM030A-S RNM050A-S.H.L	650×1325 ×600	-	Main 200	RNM050A-S 280L/h(1Mpa) RNM050A-L 600L/h(1Mpa)	

The working principle of the nanobubble device is that water and gas are supplied inside using the speed of the mixer velocity and high pressure of the gas toward the ramond which will mix and split water and gas particles into nano sizes, which are subsequently flowed out with a set discharge frequency (figure 1).

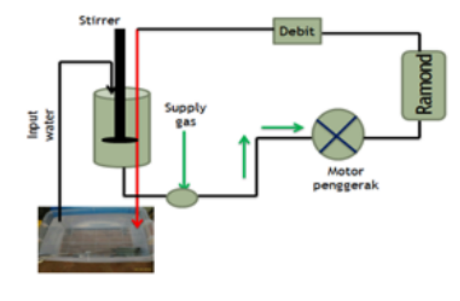


Figure 1. Working scheme of the nanobubble device.

2.3 Treatment process of cultivation media

The sample water was measured as 30 L in each treatment, then its concentration of dissolved oxygen was measured. Subsequently, the water in the treatment media were given nanobubbles with a discharge of 3 L/minute, gas flow rate 100 mL/min, driven gas pressure 0.17 Mpa, rotation speed 3050 rpm and was treated with an aerator to add oxygen. The operation time of each device was 30 minutes. After the nanobubble and aerator tools were turned off, the resulting concentration of dissolved oxygen was measured as well as the rate of decrease in oxygen in each treatment.

2.4 Measurement of rate of decrease in oxygen concentration

Eight tilapia (*Oreochromis niloticus*) with an average length of 24.5 cm was added into the water containing nanobubble oxygen with a previously adjusted oxygen concentration as the first treatment. While in the second treatment there was water containing nanobubble oxygen without fish in it. The oxygen concentration in both was measured periodically until the water was stable again at the normal water DO of 6.5 mg/L, then the time required for the dissolved oxygen in the water to return to normal was recorded.

3 Results and Discussion

3.1 Increase in oxygen concentration using nanobubble

Oxygen is one of the most important chemical elements as it is the main support of life for various organisms. Oxygen dissolved naturally in water is derived from the air diffusion and photosynthesis results of chlorophyllous organisms living in the water [3].

Dissolved oxygen is obtained through the diffusion process from the atmosphere to water and also the diffusion from the photosynthesis of algae or chlorophyllous plants in the water. Water quality is also influenced by how well the diffusion process from air to water was carried out [1].

Several species of fish can survive in water with an oxygen concentration of less than 4ppm but their appetite will start to decline. Therefore, it is necessary to increase the concentration of dissolved oxygen so that the quality of water cultivation is maintained, thus increasing the appetite and growth of fish.

The process of dissolved oxygen enrichment using nanobubble technology for a period of 30 minutes is able to increase the oxygen concentration from 6.5 ppm to 25 ppm. Rudiyanti and Ekasari [4] It is said that the a good level of dissolved oxygen for carp cultivation is between the range of 6.5 - 8.5 ppm. Increased oxygen concentrations can be seen in table 2.

Table 2. Rate of increase in dissolved oxygen.

Time interval (minute)	Concentration of dissolved oxygen (ppm)
0	6.5
5	9.9
10	13.2
15	16.4
20	19.4
25	22.5
30	25.0

3.2 Decrease of oxygen concentration in cultivation media

A decrease in oxygen concentration will result in the increase in ammonia concentration, which can be a dangerous threat to aquatic animals since a low oxygen concentration will increase the rate of respiration, decrease respiration efficiency, inhibit growth and cause mass death [5].

Dissolved oxygen is one of the indicators of water fertility. The level of dissolved oxygen decreases with the increase of organic waste in the water. This is because oxygen is also required by decomposing bacteria to decompose organic substances into inorganic substances [3]. Here are the results of measurements of the treatment in the media without fish (table 3). From the data above, it can be calculated that the rate of decrease in dissolved oxygen in the media without fish is 3.08 ppm/day.

Table 3. Rate of decrease in dissolved.

Time interval (day)	Concentration of dissolved oxygen (ppm)
1	25
2	14.8
3	11.4
4	9.3
5	7.9
6	6.6

In addition to being used for fish respiration, dissolved oxygen in water is also used by other aquatic microorganisms that live in the water, resulting in a high rate of decrease in dissolved oxygen in the water. The result of decrease in dissolved oxygen in the media treatment containing fish can be seen in table 3.

Table 4. Rate of decrease in dissolved oxygen in the media containing fish.

Time interval (Minute)	Concentration of Dissolved Oxygen (ppm)
0	25
4	20.9
8	19.6
12	18.3
16	17.1
20	16.1
24	15.1
28	14
32	13
36	11.9
40	10.9
44	10
48	9.3
52	8.6
56	7.9
60	7.2
64	6.7
68	6.1
72	5.6
76	5.2
80	4.9
84	4.5
88	4.1

Oxygen is required by fish in the catabolism process which produces energy for the fish to swim, breed, and grow. Therefore feed conversion and growth rates are highly determined by the availability of oxygen as well as other factors [1]. From the table above, it can be calculated that the rate of decrease in dissolved oxygen containing eight carp with an average body length of 24.5 cm in 30 L water is 0.23 ppm/minute (table 4).

The decrease in dissolved oxygen concentration will decline with the increasing density of fish stocking. Fish stocking density is the number of fish spread or nurtured in a certain area. Dense stocking is a very important factor affecting the success of fish cultivation.

Overly high fish density can degrade water quality, which in turn will inhibit the growth rate even though the food needs of the fish is met [6]. This is because there is competition for space and oxygen consumption in the water. Increased stocking density will be followed by an increased amount of feed, waste from body metabolism and oxygen consumption. It can also degrade water quality, causing stress to the fish so their growth decreases and they become susceptible to death [7]. Therefore, the high stocking of fish should be balanced with good environmental conditions in order to support the lives of fish and other aquatic organisms in order to produce a high production value.

4 Conclusion

From the results of treatment, it was discovered that the working principle of the nanobubble device is to combine gas and liquid and then break it down through a mixing process and high pressure so that the water and gas particles become nano-sized, enabling them to last longer in the water. The nanobubble generator can increase the dissolved oxygen in the cultivation media from the initial DO of 6.5 ppm to 25 ppm. During the nurturing period of eight carp broodstock with an average body length of 24.5 cm in 30 L of water, the nanobubble generator can be turned on for 30 minutes every 1 ½ hours. The higher the density level of the fish, the longer the nanobubble must be turned on.

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